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INNOVATIVE TECHNOLOGY
Summary Report

Portable Metal Cutting Saw for Use in D&D Operations

Deactivation and Decommissioning Focus Area

Prepared for
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INNOVATIVE TECHNOLOGY
Summary Report

Portable Metal Cutting Saw for Use in D&D Operations

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Deactivation and Decommissioning Focus Area

Demonstrated at
Los Alamos National Laboratory
Los Alamos, New Mexico

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://www.em.doe.gov/ost under "Reports".

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SECTION 1
SUMMARY

Technology Summary

The U.S. Department of Energy (DOE) continually seeks effective and safer waste handling and processing technologies for use in processing waste at nuclear facilities. To fulfill this objective, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology (OST) sponsors Large Scale Demonstration and Development Projects (LSDDP) in which developers and vendors of improved and innovative technologies showcase products that are potentially beneficial to DOE projects and to others in the D&D community. Desirable benefits include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

The Los Alamos Integrating Contractor Team of the Los Alamos National Laboratory (LANL) LSDDP evaluated the use of the Evolution 180 saw developed by Jancy Engineering as an innovative metal cutting technology that may be used in the removal of lead shielding from gloveboxes. The Evolution 180 saw resembles a carpenter's circular saw and has patented blades specifically designed for cutting metals such as stainless steel and aluminum up to a maximum thickness of 6 millimeters (mm). The blade may be used to cut metals configured as square pipe, angle steel, and flat plate. The Evolution 180 saw was used to cut the stainless steel skin from a glovebox to remove the lead shielding from the glovebox. This operation was performed inside of a glovebox enclosure at the LANL Waste Characterization, Reduction, and Repackaging (WCRR) Facility. The advantages of the Evolution 180 saw over the typical de-shielding technology included reductions in work duration, waste generation, and personnel exposure.

To establish a baseline, WCRR operations personnel were interviewed on the de-shielding technology previously used at LANL. The baseline technology used a die grinder to perform glovebox de-shielding activities. The die grinder resembles a commercially available Dremel® tool. This method was in use at LANL prior to demonstration of the innovative technology.

For the Evolution 180 saw to prove effective over the die grinder, it would be required to: 1) successfully remove the lead shielding, 2) reduce the amount of time required to perform de-shielding activities, 3) produce less waste, 4) reduce personnel exposure time, and 5) be more cost effective.

Problem

The LANL currently removes lead shielding from gloveboxes to prepare them for disposal at the Low Level Waste Burial Site at TA-54, Area G. The LANL waste inventory includes on the order of 200 "legacy" gloveboxes in temporary storage.

The estimated cost to perform de-shielding of one glovebox using die grinders is approximately $2,740. This cost is primarily composed of labor costs for operations personnel and PPE. Comparatively, the cost to perform de-shielding operations using the Evolution 180 saw is approximately $1,220. This reduction in cost results in total projected savings of $304,000 for the 200 gloveboxes that need to be processed. The cost reduction is due to a decrease in the time required to perform the operation resulting in lower labor costs and fewer entries into a contaminated area, which requires less PPE.

These gloveboxes normally have surfaces covered with ¼" (6.4 mm) lead shielding that is sandwiched and glued between the glovebox wall and a 3/32" (2.4 mm) thick stainless steel outer skin. Historically, technicians at LANL have used a die grinder fitted with a cutting wheel to size reduce these gloveboxes. The die grinder cuts through stainless steel very slowly, produces sparks as it cuts, and requires frequent replacement of the cutting wheel (See Figure 1).

Figure 1 – Die Grinder Cutting Stainless Steel (notice sparks)

Operators at the LANL indicate that the die grinder has five shortfalls; 1) it cuts at a very slow rate (0.6 inches or 15 mm per minute on average); 2) the cutting wheels wear down or fracture and must be changed routinely; 3) the grinder is difficult to force through the glovebox skin as it cuts; 4) the cutting wheel can fracture producing a high speed projectile; and 5) the cutting wheel heats the metal, which could potentially vaporize the lead.

The Evolution 180 saw was developed by Jancy Engineering Co and is marketed by HiTech USA. The Evolution 180 saw is shown in Figure 2. The saw is a portable handheld circular saw that has been shown to cut metals quickly without heating the metal or producing sparks. The saw has patented blades specifically designed for cutting metals such as stainless steel and aluminum up to a maximum thickness of ¼" (6 mm). The blade may be used to cut metals configured as square pipe, angle steel and flat plate. The blade life is dependent on the material being cut and its geometry. For stainless steel plate, the blade life is 700 minutes. The saw weighs about 13 pounds (5.9 kg) and is 21 inches (53 cm) in length. The unit is actuated with an on/off guarded trigger switch and is supported with a supplemental handgrip mounted near the front of the saw. Features include: a depth adjustment mechanism, a fixed upper and a retractable lower blade guard to prevent contact with the blade while cutting, an EMC filter, an overload switch, and a dust cover for collecting metal shavings.

Figure 2 - Jancy Engineering Evolution 180 Saw Model #EVMC07

Demonstration Summary

Information on the operation of the Evolution 180 saw was collected from WCRR operators who performed the glovebox de-shielding operation. The Evolution 180 saw Model #EVMCO7 was used in place of a die grinder for an ongoing glovebox de-shielding removal operation at the WCRR Facility. The saw was used to cut through the glovebox outer skin to remove lead shielding from the walls of a 36 inch (91 cm) high x 31 inch (79 cm) deep x 42 inch (107 cm) wide glovebox.

Information on the baseline technology, the die grinder, was taken from discussions with the same WCRR operations personnel who had removed the lead shielding from a previously sectioned glovebox.

Results

The Evolution 180 Saw was successfully used at the LANL with the following key results:

- The Evolution 180 saw successfully cut through the 3/32" (2.4 mm) stainless steel glovebox skin at cutting speeds up to 5.8 inches (15 cm) per minute which was approximately 10 times faster than the die grinder.
- Setting the depth of cut to avoid cutting the lead shielding beneath the stainless steel outer skin was easily accomplished.
- The operators felt that the Evolution 180 required very little force to cut through the metal.
- The saw produced no sparks.
- An external vacuum hose successfully removed saw cut debris.

Benefits:

- Glovebox shielding was removed more quickly.
- Decreased potential for lead contamination while cutting.
- Decreased number of cutting blades to accomplish the work, enhancing operator safety and reducing cost.

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Other

All published Innovative Technology Summary Reports are available on the OST Web site at http://www.em.doe.gov/ost under "Reports". The Technology Management System (TMS), also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST/TMS ID for the Evolution 180 Saw is 3234.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

Innovative Technology

The overall objective is to evaluate the performance of the Evolution 180 on its ability to quickly and safely cut stainless steel and perform de-shielding operations. The information collected is based on information supplied by the operators who performed the glovebox de-shielding operation using the Evolution 180 saw. The Evolution 180 saw was used to de-shield a glovebox at LANL's TA-50 WCRR Facility. The operation was performed in an 8-foot (2.4 m) wide by 15-foot (4.6 m) long by 15-foot (4.6 m) high enclosure (See Figure 3).

Figure 3 – Glovebox Within Enclosure Before Cutting

The internal surfaces of this enclosure were covered with flame resistant plastic sheeting, to protect them from lead contamination. Additionally, a plastic sheet was hung from the roof of the enclosure to divide the enclosure into an inner and outer doffing area. Operators used a forklift with a boom attachment to move the glovebox into the enclosure and positioned it on the floor. Equipment in the enclosure included a portable vacuum system (to capture any lead dust dispersed by the saw), a hammer, chisel, and crowbar (to remove the shielding once the stainless steel outer skin was removed).

Four workers were required to perform this activity: two saw operators, a supervisor, and a radiological control technician (RCT). The operators performing the work wore full-face respirators with lead cartridges, inner and outer pairs of anti-c coveralls with booties, plastic glove liners with leather gloves, and Tyvek® hoods. The supervisor, wearing PPE, and the RCT remained outside the enclosure to perform monitoring and surveying activities. Before leaving the work area within the enclosure, the outer pair of anti-contamination (anti-c) coveralls and hood (Tyvek® covering) and leather gloves that were potentially contaminated with lead were removed. The remaining PPE was removed in the normal doffing area.

To remove the lead shielding, the depth of the outer layer of the glovebox stainless skin was confirmed. Then the cutting depth was set so that in the event of a miscut the blade would make minimal contact with the lead beneath the glovebox skin. The glovebox skin was cut along pre-determined paths where the saw blade could travel without contacting the lead plates (see Table 2). One operator operated the saw, while the other operator held the glovebox skin being cut off. The second operator also manipulated the vacuum hose and performed a safety watch for the location of the blade with respect to the locations of both pairs of hands. After the glovebox skin was cut, the glovebox skin was removed or bent out of the way so that the lead shielding was exposed for removal. The operators used the hammer, chisel, and crowbar to remove the lead shielding by prying it loose. Surface smear samples were taken after the shielding was removed. The glovebox skin and the de-shielded glovebox were packaged in the original container for disposal as LLW.

Figure 4 - Evolution 180 Saw Cutting Glovebox Skin

<u>Baseline Technology</u>

The baseline technology differs from the innovative technology in the tool used to perform the de-shielding operation. Additional time is required and two technicians perform the de-shielding operation, each using a die grinder. Additional entries and exits into the enclosure are required to perform the same amount of work as the innovative technology.

The baseline technology was not observed. The information supplied was obtained from WCRR operations personnel who have performed de-shielding operations using the die grinder.

System Operation

Table 1 summarizes the parameters for the Evolution 180 saw.

Table 1: Operational parameters and conditions for Evolution 180 saw Demonstration

Working Considerations	
Labor Required	
Work Crew	Two operators (one saw operator and one assistant) One supervisor in PPE and respirator outside of the enclosure overseeing ventilation One RCT
Work Area Hazards	Potential airborne lead contamination Potential airborne radioactivity Cutting hazard Sharp edges
Extra Support Personnel	None
Waste Management	
Primary Waste Produced	Over 100 pounds of lead plates, in various sizes.
Secondary Waste Produced	Used saw blades (saw blade life is 700 minutes, so saw blades would only be changed after several evolutions), PPE, plastic sheeting. Used saw (after approximately 1 year of use)
Equipment Specifications and Features	
Technology design purpose	Metal Cutting
Maximum Depth of Cut	¼"(6 mm), operator set
Blade	7"(180 mm) diameter, 0.078" (2 mm) thick
Motor	120 V, 1200W, 60 Hz, 3500 RPM
Quality of cut	Jagged and sharp edges
Dimensions	Evolution 180 saw: 21" (53 cm) L x 10-3/16" (26 cm) W x 9" (23 cm) H; 13 lb (5.9 kg)
Portability	Easily transported to the site.
Materials Used	
Work Area Preparation	A portable vacuum unit and hose is used to collect any lead dust produced while cutting.
Personnel Protective Equipment	3 sets Tyvek® anti-contamination suits, outer gloves, hood, and booties. 3 pairs rubber shoe covers 3 pair leather gloves 3 respirators with lead cartridges
Utilities/Energy Requirement	
Power	120 volt, 10 amp

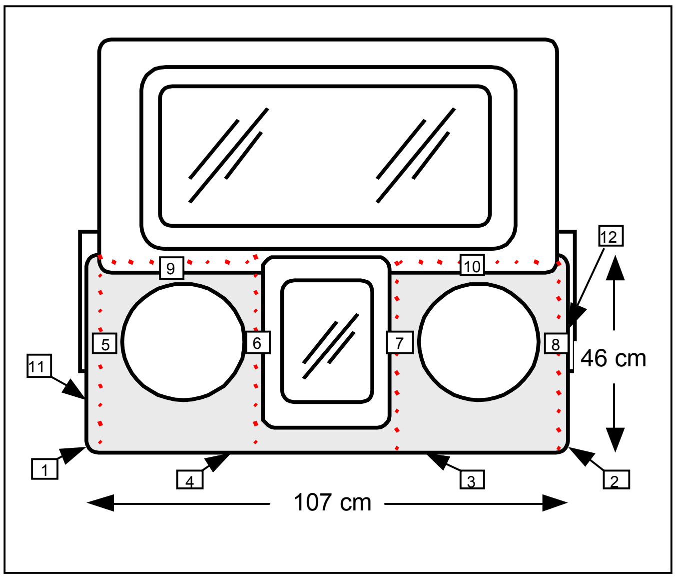
SECTION 3
PERFORMANCE

Demonstration Plan

The glovebox used for the demonstration was 36 inches (91 cm) high x 31 inches (79 cm) deep x 42 inches (107 cm) wide with lead shielding sandwiched inside the bottom and the front surfaces. The weight of this glovebox was approximately 320 pounds (145 kg). This glovebox had ¼” (6.4 mm) lead shielding inside the front wall and the floor which was covered with a 3/32” (2.4 mm) thick stainless steel skin.

Table 2 shows the areas containing lead and delineates the cuts that must be made in the skin allowing the lead to be removed.

Table 2 – Glovebox Dimensions and Removal Sequence



Cut		Cutting Length (in)	(cm)	Orientation
1	Lower left side	31	79	Horizontal
2	Lower right side	31	79	Horizontal
3	Lower back side	42	107	Horizontal
4	Lower front side	42	107	Horizontal
5	Face cut No. 1	18	46	Vertical
6	Face cut No. 2	18	46	Vertical
7	Face cut No. 3	18	46	Vertical
8	Face cut No. 4	18	46	Vertical
9	Face cut No. 5	17	44	Horizontal
10	Face cut No. 6	17	44	Horizontal
11	Left side	18	46	Vertical
12	Right side	18	46	Vertical
	TOTAL	**289**	**734**	

Innovative Technology

The principal goal of the project was to evaluate whether the Evolution 180 saw could cut the glovebox walls in order to remove the lead plates more safely and effectively than the die grinder. One operator manipulated the saw while a second operator assisted with manipulating the glovebox, lead removal, and providing a safety watch to prevent injury.

Data collected from the operators included the work duration, the number of entries and exits made, materials, mobilization and demobilization times. On Day 1, the operators made cuts numbers 1 - 4 and removed the lower left, right, front, and back sides of the glovebox skin and then removed the lead shielding. On Day 2, the operators made cuts numbers 5 - 12 and removed the face, left, and right sides of the glovebox skin and then removed the lead shielding.

Details of the time required for the operators to perform these tasks, along with the support personnel required, are contained in the Cost Section 5.

Baseline Technology

Based on the use of the die grinders and in order to establish a baseline, estimates for the work duration, the number of entries and exits made, materials, and mobilization and demobilization times were obtained from the same operators who performed the Evolution 180 saw operation.

The WCRR operations personnel stated that to cut approximately one foot (30 cm) of material takes 20 minutes. Also, in the time that it takes to cut one foot of material up to three die grinder wheel replacements may be required. Both technicians use die grinders. Four evolutions are generally required to de-shield one glovebox.

Mobilization time and area preparation times are the same as the innovative technology. PPE is the same as the innovative technology with the exception that additional PPE is used due to the additional entries and exits required to complete the de-shielding operation.

An estimate of the approximate times for the operators and for the required support personnel to complete each task of the de-shielding operation is shown in the Cost Section 5. This estimate is based on 4 entries of approximately 2 hours each.

Results

The Evolution 180 saw operation was performed at the WCRR Facility between June 16 and June 18, 2002. The enclosure was covered with plastic sheets before performing the operation. The glovebox was delivered to the WCRR Facility with gloveports, windows, and flanges taped and the legs removed.

First the floor shielding was removed and then the shielding on the front of the glovebox was removed. Table 2 includes the glovebox dimensions and the sequence that was followed during the glovebox de-shielding operation. The shielding at the front surface required cuts along the front left and right sides and around the gloveports and window (See Figure 5). To insure the blade remained clear of the glove rings (no breaching), the operators made vertical cuts so that the skin could be bent out of the way for access to the underlying lead shielding.

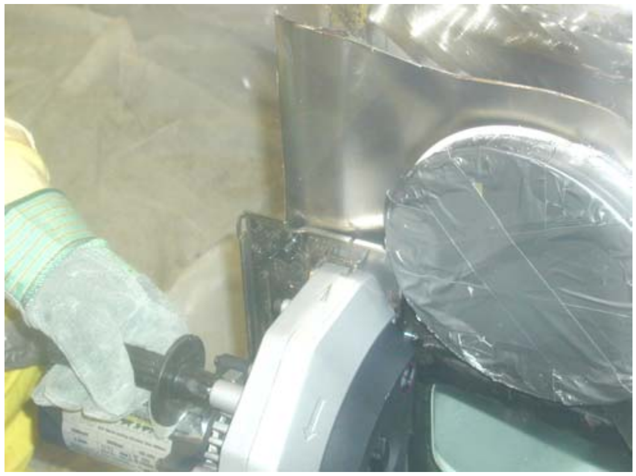


Figure 5 – Evolution 180 Saw Cutting around Gloveports

Approximately 24 feet (734 cm) of 3/32” (2 mm) thick stainless steel was cut to remove the lead shielding. The operation required two entries: a 2 hour morning session, and a 2-1/2 hour afternoon session. The actual cutting tasks took approximately 50 minutes. Based on the time estimated to perform these cuts and the dimensions given in Table 2, the saw achieved an average cutting speed of 5.8 inch/min (15 cm/min). The lengths are approximate since each section was not cut perfectly straight. It was noted that the cutting rate for the Evolution 180 saw was almost constant for all cuts and was almost ten times faster than the die grinder, which averages 20 minutes to cut one foot (0.6 inch/min or 15 mm/min).

Other Factors

- Operational Safety
  The operators felt that the Evolution 180 saw cut through the stainless steel with much less effort than the die grinder. Noise levels were about the same for both tools, within the 50 to 90 dB limits. Unlike the die grinder, the Evolution 180 saw produced no sparks as it cut. The weight of the saw could rest on the piece being cut, whereas the die grinder had to be supported at all times.

- Ease of use
  A left-handed operator found the saw awkward to control at first, but then became accustomed to the saw. The operator noted that on the right-handed model saw, the safety switch was inconveniently located for a left-handed operator. Both saw operators felt the Evolution 180 saw was easy to use, similar to a circular saw cutting through wood.

- Mobilization/Demobilization
  The walls of the enclosure were covered with fire retardant a few days before the demonstration, approximately 8 hours. The glovebox was moved into the enclosure one day before the demonstration with a forklift in about 30 minutes. During the operation workers donned PPE, which took 15 minutes, while doffing PPE, took 20 minutes.

- Waste Generation
  The Evolution 180 saw produced far less dust as it cut than the baseline technology. A new saw blade was not needed since the saw was in operation for only 50 minutes.

  The die grinder would be expected to require a significant number of die grinder wheel replacements. Based on information obtained from the operators, typically, three wheel replacements are needed for every foot (30 cm) of material that is cut.

  For both technologies waste PPE, consisting of inner and outer gloves and outer coverings, was produced for three people. For the Evolution 180 saw operation two sets of PPE were generated. For the baseline technology typically four sets of PPE are used since the operators must perform two additional entries to accomplish the same amount of work.

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

The glovebox shielding removal operation precludes cutting technologies employing tools with jaws such as nips or sheers because there is virtually no space between the glovebox outer skin and the lead shielding for placement of the lower jaw of the tool to grab to make cuts. Additionally, heated cutting tools such as torches cannot be used because high temperatures will cause the lead vaporize. The cutting technology selected must be a saw or grinder. The baseline technology that competes with the Evolution 180 saw is the variable speed die grinder used at LANL to cut and size reduce metallic gloveboxes. There are other metal cutting circular saws on the market, but these saws have not been evaluated at LANL. Regardless of the technology selected, the glovebox skin must be cut carefully so that the blade does not nick the lead shielding and produce lead dust and the blade used must not cut the glovebox (inner) walls which could result in spreading radiation.

The Rocky Flats Environmental Technology site is routinely removing gloveboxes using a plasma torch. As indicated above, that is unacceptable in this application.

Technology Applicability

The Evolution 180 saw is well suited for dismantlement and volume reduction of metallic waste with a maximum thickness of ¼" (6 mm). Thus, Los Alamos LSDDP selected the Evolution 180 as a simple means of size reducing gloveboxes and other large enclosures and shapes. The Evolution 180 saw is a fully developed and commercially available tool for cutting stainless steels, aluminum, and other metals. Its superior performance over the baseline die grinder in cutting rate, worker safety, and ease of use make it a prime candidate technology for use throughout the DOE complex. This technology could be integral to the volume reduction of gloveboxes and has the potential to speed up dismantlement schedules and significantly reduce D&D costs. While it is noted that typical training would be limited to a general instruction in small tool usage, use of this technology requires an increased emphasis on operational safety due to the hazards involved with the rotating blade.

Typical applications in the private sector for this saw include cutting metal plate legs, pipe, conduit, and other metallic geometries quickly and safely. This tool represents a very effective, easily maneuverable means of cutting stainless steels and aluminum.

Patents/Commercialization/Sponsor

The Evolution 180 saw is a fully developed technology, and is distributed commercially through HiTech USA. Any patents are held by the company.

SECTION 5
COST

Methodology

The objective of the cost analysis was to provide an estimate for implementing the use of the Evolution 180 saw for removing shielding from gloveboxes at a DOE site. The Evolution 180 saw technology was evaluated at LANL under controlled conditions.

The baseline technology requires two Milwaukee Die Grinders to perform de-shielding operations. Although this cutting technology was not used during the demonstration, workers who have used it in the past report a maximum cutting speed of 1 foot (30 cm) every 20 minutes. This estimate includes three grinder wheel change-outs per foot (30 cm) as a result of frequent wheel breakage.

A per-glovebox unit cost was developed from the demonstration results. Key assumptions for this cost estimate are listed below. Other assumptions and details considered in this cost analysis are discussed in Appendix B.

- For a realistic comparison, it was assumed that each technology would be utilized to process all of the legacy 200 gloveboxes.
- New equipment costs and resulting equipment wastes were amortized for each technology on a per glovebox basis for the 200 glovebox operation.
- A DOE site, such as LANL, will purchase both tools and supporting equipment for deployment.
- The costs for job control materials such as plastic sheeting and fire retardant and the costs for preparation of the enclosure, insertion of the glovebox, and removal of material were not considered because they were the same for both technologies.
- The cost of the portable vacuum and other tools supporting the operation were not considered, as these are standard equipment not specifically purchased for this evaluation.
- It was assumed that the work team for both technologies consists of four workers: two workers operating the tool(s) inside the work zone, and both a supervisor in PPE and an RCT (not in PPE) outside the work zone.
- Fully burdened labor rates for LANL personnel were used in the estimate.
- Costs for work permits were not considered.
- Work hours for worker briefings were not considered.
- No overhead factors were applied to other direct costs.
- Since the cost of both tools is low, they were considered as expendable items (no repairs).
- The cutting rate for the die grinder was assumed to be constant at 1 foot (30 cm) every 20 minutes. (This assumption includes time for changing blades.)
- The cutting speed of the Evolution 180 saw averaged 1 foot (30 cm) every 2 minutes.
- Glovebox cutting rates were based on cutting gloveboxes with a 3/32” (2.4 mm) 304 stainless steel skin.
- Blade consumption for the Evolution 180 saw was assumed to be one blade for every 700 minutes of operation.
- Although contamination is an issue at LANL, no decontamination time was assumed, as both tools will remain within the enclosure when not actually in use.
- The estimated lifetime for each tool is 800 hours of continuous operation; therefore no tool change-out was anticipated.
- Waste disposal costs for lead shielding and removed stainless steel were not considered.

Cost Analysis

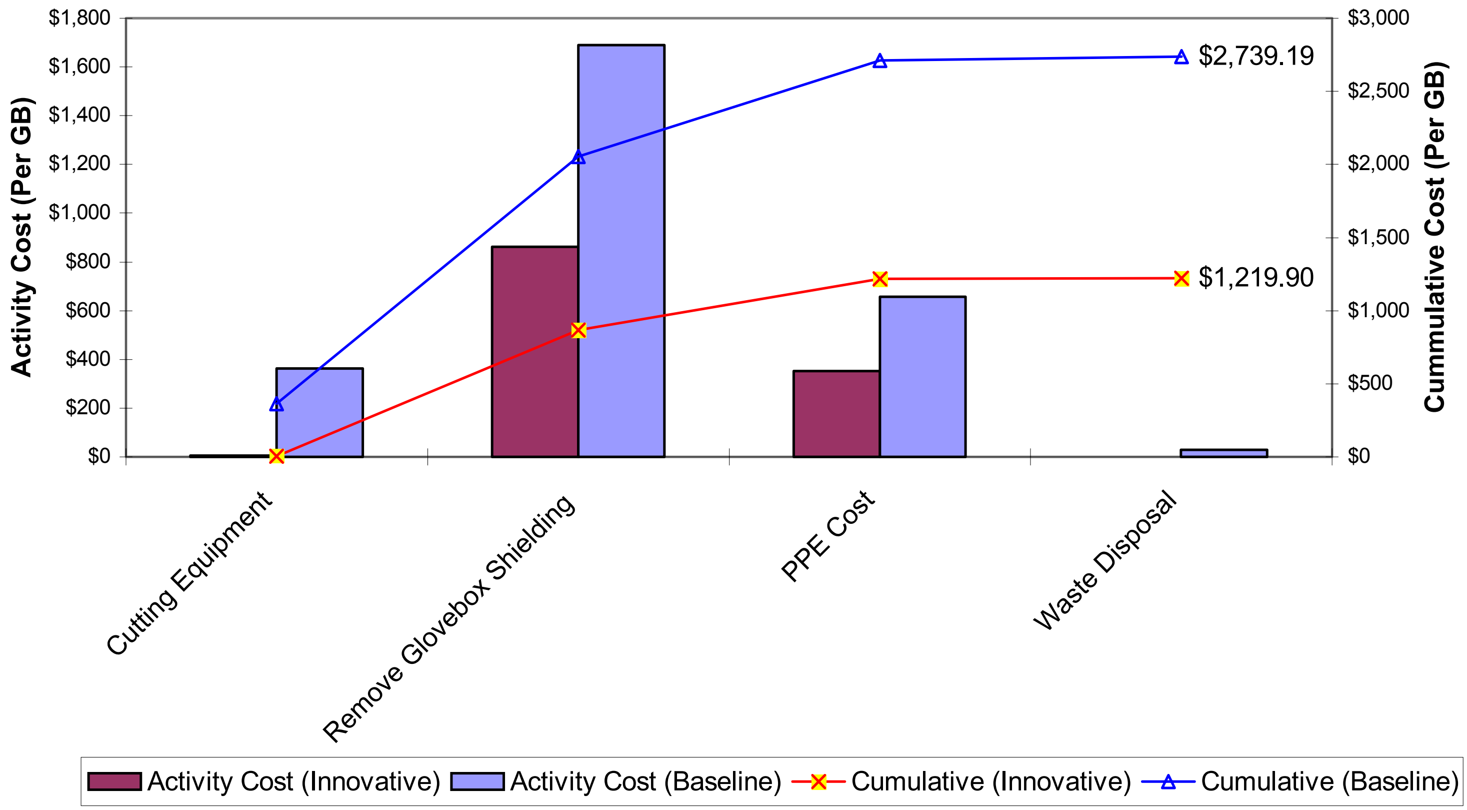
The implementation cost estimate is based on a cost per glovebox. Activities were grouped under higher level work titles per the work breakdown structure shown in the Hazardous Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS) (U.S. Army Corps of Engineers, 1996).

Figure 4 summarizes the results of the cost analysis. It compares the Evolution 180 saw unit costs to the baseline. The bars indicate the cost of each activity on a cost per unit basis, and the line represents the sum of the costs. The raw data to support production rate calculation can be found in Tables B-1 and B-2 in Appendix B).

Cost Conclusions

The estimated cost to perform de-shielding of one glovebox using die grinders is approximately $2,740. By comparison, the cost to perform de-shielding operations using the Evolution 180 saw is approximately $1,220. This results in estimated savings of $304,000 for the 200 gloveboxes to be processed. Figure 4 illustrates the estimated costs for each technology detailed by the major cost elements. Further details of the cost estimates are contained in Appendix B.

Figure 4 – Unit Costs for Evolution 180 Saw vs. Baseline



SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

The following safety and health regulations govern the regulatory/permitting issues related to the of the Evolution 180 saw at LANL.

Occupational Safety and Health Administration (OSHA) 29 CFR 1926

1926.300 to 1926.307	Tools – Hand and Power
1926.400 to 1926.449	Electrical - Definitions
1926.28	Personal Protective Equipment
1926.102	Eye and Face Protection
1926.103	Respiratory Protection

Occupational Safety and Health Administration (OSHA) 29 CFR 1910

1910.211 to 1910.219	Machinery and Machine Guarding
1910.241 to 1910.244	Hand and Portable Powered Tools and Other Hand-Held Equipment
1910.301 to 1910.399	Electrical Definitions
1910.132	General Requirements (Personal Protective Equipment)
1910.133	Eye and Face Protection
1910.134	Respiratory Protection

Safety, Risks, Benefits, and Community Reaction

The operators who used the Evolution 180 saw in the demonstration found it safer to use and easier to handle than the die grinder. It produced less airborne contamination, posing less risk to workers and the environment.

However, additional hazards exist with the use of a partially exposed rotating blade. Therefore operators must be made aware of these possible upset conditions and how to react to each situation:

- Kickback, or the sudden reaction to a pinched blade, is possible with this saw and could cause the saw to tilt up, out and toward the operator. Adopting a proper working position that allows the operator to cut a smooth straight line without strain or discomfort will ensure operation of the saw without binding and kickback.
- Care should be exercised to support the work piece properly and to not force the tool.
- Care must also be taken to set the blade exposure or depth of cut accurately so as not to cut into the lead beneath the stainless steel cover surface.

Since the work progresses more quickly with the Evolution 180 saw workers have reduced exposure to the contaminated environment.

Although not relevant to this application, in comparison to flame cutting, less training is required and the hazards associated with using a hot torch are avoided.

SECTION 7
LESSONS LEARNED

Implementation Considerations

- Operators using the Evolution 180 saw must perform work with increased vigilance and regard to personal safety in the confined area.
- Only workers with enough dexterity and satisfactory spatial visual skills should be chosen to handle the saw. Workers should become familiar with the saw operation before entering the work area.
- The material to be cut, thickness, and position should all be determined before starting work to ensure proper performance.
- Remove any excess mill scale or rust from the surface to be cut.
- Material that has been flame cut may have become heat-treated and therefore will be more difficult to cut. Avoid cutting near such areas whenever possible.
- The metal being cut must be oriented perpendicular to the blade otherwise blades can be broken or bent. Flat surfaces are the best application.
- Cuts must be as straight as possible to avoid blade binding and possible kickback.
- For gloveboxes housing radiological materials, pass-in and pass-out ports, and gloveports should be surveyed for radioactive contaminated lead removal.

Technology Limitations and Needs for Future Development

- The Evolution 180 saw is designed for a right-handed person. One worker taking part in the demonstration was left-handed, and stated that while he found it awkward to use the tool at first; he soon became familiar with the saw and was able to operate it safely and effectively.
- There was some difficulty cutting around glove ports because tight radius turns cannot be safely performed with this tool. The baseline technology may be better for cutting around corners.

Technology Selection Considerations

This technology is suitable for use at DOE nuclear facilities or other D&D sites where piping, conduit, or metal parts have to be removed and size reduced.

APPENDIX A
REFERENCES

U.S. Army Corps of Engineers (USACE). 1996. Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure, Prepared for the U.S. Department of Energy, draft January.

Hazardous, toxic, radioactive waste remedial action work breakdown structure and data dictionary, 1996, Headquarters United States Army Corps of Engineers.

APPENDIX B
TECHNOLOGY COST COMPARISON

Basis of Estimated Cost

The cost estimate compares the costs associated with implementing the Evolution 180 saw versus the Milwaukee Die Grinder to remove shielding from gloveboxes. The actual demonstration costs incurred at LANL formed the basis of the cost estimate and were extrapolated to determine actual expenses. The estimate is based on the time needed to de-shield one glovebox with equipment and waste disposal costs amortized over a one year campaign to complete 200 gloveboxes.

Activity Descriptions

The scope of each WBS element, calculation of production rates, and assumptions (if any) for each work activity is described in this section.

Mobilization (WBS 33.1.01)

Mobilization of Equipment – The mobilization time required to prepare the enclosure for de-shielding operations is the same for both technologies.

Glovebox Transport to Enclosure – The time required to transport a glovebox to the enclosure is the same for both technologies.

Innovative Technology - It was assumed in this cost analysis that LANL will purchase an Evolution 180 saw for use at LANL. The saw cost approximately $300.00 (without blade) and the stainless steel cutting blade cost $57.95. Each blade is rated to operate for 700 minutes when used to cut stainless steel plating, so each blade should last long enough to process 14 gloveboxes (700 min/blade/50 min/GB = 14 GB). In order to amortize these costs for processing all 200 gloveboxes, the quantity factor 0.005 (1/200) was used for the saw and 0.071 (1/14) for the blade.

The saw was operational for only 50 minutes for one glovebox, however to complete all 200 gloveboxes approximately 14 additional blades will be required. (50 min/GB X 200GB/700 min/blade = 14 additional blades)

Baseline Technology – It was assumed that LANL would purchase 2 Milwaukee Die Grinders to use in glovebox shielding operations. Each unit costs approximately $290.00. In order to amortize the cost for processing all 200 gloveboxes, the quantity factor 0.01 (2/200) was used for the die grinders.

Replacement blades are available from the vendor at $5.00 each. The operators have stated that at least three wheels will be used per foot (30 cm) of stainless steel that is cut. During the demonstration, 24 feet (7.3 m) of stainless steel was cut which would require 72 cutting wheels (3 X 24) to complete each glovebox.

Submittals/Implementation Plans – Plans were assumed complete before start of work. No permits were required.

Monitoring, Sampling & Testing (WBS 33.1.02)

Innovative Technology - Monitoring, sampling and testing costs take into account PPE costs as well as labor costs associated with the day's activities. Both operators and the supervisor outside the area wore PPE. All three workers took 15 minutes to don their PPE and 20 minutes to doff their PPE. A total of two entries were made during the demonstration, one entry was performed for every two hours of operation.

In the demonstration, 24 feet (7.3 m) of glovebox skin was cut in 50 minutes, yielding an average cutting speed of approximately 5.8 inch/min (14.7 cm/min). The demonstration required two entries and exits, and a total work time of 4.5 hours. Table B-1 indicates the observed times to complete the essential tasks of the de-shielding operation. These activity times were used to develop the cost estimate.

Table B-1: Demonstration Data

Workers	Activity	Day 1	Day 2	Time Totals	
		Time (min)	Time (min)	(min)	(hr)
2 Operators	Don PPE	15	15	30	0.5
	Cut GB	15	35	50	0.8
	Remove Lead/Manipulate GB	55	45	100	1.7
	Packaged Waste	15	35	50	0.8
	Doff PPE	20	20	40	0.7
	Subtotal	120	150	**270**	**4.5**
1 Supervisor	Monitoring	120	150	**270**	**4.5**
1 RCT	Surveying	150	150	**270**	**4.5**

Baseline Technology - The die grinder cutting speed, based on operator experience, was 1 foot (30 cm) every 20 minutes, or 0.6 inch/min (15 mm/in). For an equivalent glovebox (i.e., 24 feet or 7.3 m of cutting) with two technicians operating die grinders, approximately 480 minutes would be needed to cut up the glovebox. Using work task durations established for the innovative technology and extrapolating the data, the baseline technology would take almost 9 hours to complete. Table B-2 lists typical baseline data which was developed assuming four 2 hour (approximately) entries to complete the grinding, lead removal/manipulation, and packaging tasks.

Table B-2: Baseline Data

Worker	Activity	Entry 1	Entry 2	Entry 3	Entry 4	Time Totals	
		Time (min)	Time (min)	Time (min)	Time (min)	(min)	(hr)
2 Operators	Don PPE	15	15	15	15	60	1.0
	Cut GB	95	70	45	30	240	4.0
	Remove Lead/Manipulate GB		25	25	50	100	1.67
	Packaged Waste			25	25	50	0.83
	Doff PPE	20	20	20	20	80	1.3
	Subtotal	130	130	130	140	**530**	**8.8**
1 Supervisor	Monitoring	130	130	130	140	**530**	**8.8**
1 RCT	Surveying	130	130	130	140	**530**	**8.8**

Decontamination (WBS 33.1.02)

It was assumed that there were no costs incurred for either technology since all equipment used for the demonstration either remains within the area, or is disposed of as LLW.

Demobilization (WBS 33.21)

There are no demobilization costs associated with the baseline or innovative technologies.

Waste Disposal (WBS 33.1.18)

Innovative Technology - The wastes produced during the demonstration included 6 sets of PPE per glovebox. Although the saw blade was not replaced during this evolution, 14 additional blades will be used and discarded during the campaign to de-shield 200 gloveboxes. The saw itself will also be discarded at the end of the campaign.

Waste disposal volume estimates for the saw (21" X 10-3/16" X 9" = 1925 in^3 = 1.1 ft^3 or 0.03 m^3) and the blades ([3.1417 X 7"$Ø^2$ X 0.078" X 14 Blades]/4 = 42 in^3 = 0.024 ft^3, say 0.03 ft^3 = 0.00085 m^3) were developed. The total waste estimate was rounded off to 1.15 ft^3 (0.03 m^3) and at \$204/ft^3 (\$7,200/m^3), it would cost approximately \$235 to dispose of this TRU waste. In order to amortize this cost over all 200 gloveboxes, a quantity factor of 0.006 (1.15/200) was used.

Baseline Technology - Wastes produced by performing the de–shielding operation with the baseline technology would include 12 sets of PPE per glovebox. After de-shielding 200 gloveboxes, the die grinders and wheels would be discarded. Approximately 72 die grinder wheels would be discarded per glovebox processed, for a total of 14,400.

The waste volume of each die grinder is assumed to be approximately equal to the Evolution 180 saw or 1.1 ft^3 (0.03 m^3). The estimated ([3.1417 X 4"$Ø^2$ X 0.25" X 14,400 disks]/4 = 45,240 in^3 = 26.2 ft^3) waste volume of the grinder wheels is 26.2 ft^3 (0.74 m^3) for a total waste volume of 28.4 ft^3 (0.8 m^3). At \$204/ ft^3 the total cost of waste disposal would be \$5,794 which was amortized over all 200 gloveboxes by applying a quantity factor of 0.142 (28.4/200).

Equipment Cost

The innovative technology and the baseline technology require PPE to fulfill RWP requirements. This cost includes the daily costs of PPE, respirator-cleaning costs, and laundry costs. Cost data for PPE were found in a Lab Safety Supply catalog. UniTech estimated the cost of laundry service, including transportation, as \$4.00 per unit. Each unit consists of coveralls, shoe covers and gloves.

Each respirator must be sent to E-ET at LANL for cleaning, then to ESH-5 for assembly and testing once per month at a cost of approximately \$260.00. Based on a one year campaign to process 200 gloveboxes, the total cleaning cost per respirator is 12 mo. X \$260/mo. = \$3,120 per worker/year. Therefore, the amortized cost per glovebox per worker is \$3,120/200 = \$15.60.

Cost breakdowns for the remaining PPE can be seen in Tables B-3 and B-4 on a per glovebox basis for each technology.

The material cost for the sheeting and vacuum and other equipment and tools used to prepare the site were not considered in this analysis.

Table B-3: Innovative Technology Implementation Cost

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	TOTAL
Mobilization and Preparatory Work (WBS 33.1.01)							**$5.62**
Evolution 180 Equipment							*$5.62*
			Evolution 180 saw	Ea. (amort.)	$300.00	0.005	$1.50
			Replacement Blades	Ea. (amort.)	$58.00	0.071	$4.12
Monitoring, Sampling & Testing (WBS 33.1.02)							**$1,213.06**
Remove Glovebox Shielding							*$860.80*
	Technician	2	Remove Glovebox Shielding	Hour	$48.00	3.3	$316.80
		2	Don PPE and enter enclosure	Hour	$48.00	0.5	$48.00
		2	Doff PPE and exit enclosure	Hour	$48.00	0.7	$64.00
	Supervisor	1		Hour	$48.00	4.5	$216.00
	RCT	1		Hour	$48.00	4.5	$216.00
PPE (2 entries by 2 techs + 1 supr in PPE)							*$352.26*
			Tyvek Coverall	Ea.	$24.00	6	$144.00
			Tyvek Hood	Ea.	$3.36	6	$20.16
			Leather gloves	Pair	$10.00	6	$60.00
			Gloves N-DCR	Pair	$0.20	6	$1.20
			Gloves Nitric/Latex	Pair	$1.35	6	$8.10
			Respirator Cartridge	Set	$8.00	6	$48.00
			Respirator Cleaning (1/mo)	Ea. (amort.)	$15.60	3	$46.80
			PPE Laundry Service Fee	Unit	$4.00	6	$24.00
Waste Disposal (WBS 33.1.18)							**$1.22**
			Saw and used blades (amort.)	Cubic Feet	$204.00	0.006	$1.22
TOTAL COST							**$1,219.90**

Table B-4: Baseline Technology Implementation Cost

TITLE	LABOR	LABOR QUANTITY	EQUIPMENT	UNIT OF MEASURE	UNIT COST	QUANTITY	TOTAL
Mobilization and Preparatory Work (WBS 33.1.01)							**$362.90**
Die Grinder Equipment							*$362.90*
			Die Grinder	Ea. (amort.)	$290.00	0.01	$2.90
			Replacement Disks	Ea. (amort.)	$5.00	72	$360.00
Monitoring, Sampling & Testing (WBS 33.1.02)							**$2,347.32**
Remove Glovebox Shielding							*$1,689.60*
	Technician	2	Remove Glovebox Shielding	Hour	$48.00	6.5	$624.00
		2	Don PPE and enter enclosure	Hour	$48.00	1.0	$96.00
		2	Doff PPE and exit enclosure	Hour	$48.00	1.3	$124.80
	Supervisor	1		Hour	$48.00	8.8	$422.40
	RCT	1		Hour	$48.00	8.8	$422.40
PPE (4 entries by 2 techs + 1 supr in PPE)							*$657.72*
			Tyvek Coverall	Ea.	$24.00	12	$288.00
			Tyvek Hood	Ea.	$3.36	12	$40.32
			Leather Glove	Pair	$10.00	12	$120.00
			Gloves N-DCR	Pair	$0.20	12	$2.40
			Gloves Nitric/Latex	Pair	$1.35	12	$16.20
			Respirator Cartridge	Set	$8.00	12	$96.00
			Respirator Cleaning (1/mo.)	Ea. (amort.)	$15.60	3	$46.80
			PPE Laundry Service Fee	Unit	$4.00	12	$48.00
Waste Disposal (WBS 33.1.18)							**$28.97**
			Die grinder and disks (amort.)	Cubic Feet	$204.00	0.142	$28.97
TOTAL COST							**$2,739.19**

APPENDIX C
ACRONYMS AND ABBREVIATIONS

DOE	U.S. Department of Energy
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
HTRW RA WBS	Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure
ITSR	Innovative Technology Summary Report
LLW	Low Level Waste
LSDDP	Large-scale Demonstration and Deployment Project
OST	Office of Science and Technology
PPE	Personal Protective Equipment
RCT	Radiation control technician
WBS	Work Breakdown Structure
WCRR	Waste Characterization, Reduction, and Repackaging